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(54) IMPROVED COOLING PROCESS FOR METAL WIRE OR ROD

(71) We, DEMAG AKTIENGESELLSCHAFT, a Body Corporate organised under the laws of the Federal Republic of Germany, of 4100 Duisburg, Wolfgang Reuter Platz, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of cooling hot metal wire or rod leaving the final stand of a rolling mill.

The process used to cool metal wire or rod after it has been hot rolled affects its quality and is also of economic significance. Various different cooling processes are currently in use or have been proposed but suffer from one disadvantage or another. Thus, one type of process may cool the wire or rod insufficiently during the time available, another may cool the wire or rod irregularly, while yet another may result in undesirable changes in the structural composition of the metal.

The present invention seeks to overcome these drawbacks and starts from the realisation that cooling of hot wire or rod leaving a rolling mill should be carried out intermittently so that short cooling phases are interspersed with phases during which equalisation of the temperature of the stock can take place, the overall cooling process being carried out rapidly, but not too rapidly, so that scale formation is limited while the structure consists of ferrite and a preponderant quantity of pearlite.

According to one aspect of the present invention, there is provided a method of cooling hot metal wire or rod leaving the final stand of a rolling mill, wherein the wire or rod is wound under tension into a coil composed of a plurality of superimposed layers of turns, the innermost layer of the coil being supported during winding; the winding operation being carried out by rotating the coil about its axis; the cooling operation being carried out using liquid coolant in such a way that each segment of each turn of the coil is subjected alternately to a cooling phase (wherein it is subjected to the action of coolant) and a temperature equalisation phase.

In this way, the wire or rod (hereinafter referrred to for convenience as "stock") wound onto the drum is cooled intermittently, that is to say, the stock includes zones which are being subjected to forced cooling with the aid of coolant, alternating with zones which are being allowed to cool naturally in air. This results in the stock near the surface of the coil which has been cooled being reheated by the heat escaping from within the cross-section, so that a temperature equalisation occurs across the cross-section of the stock. The resulting cooling process is substantially uniform throughout the whole thickness, the cooling time is short, the structure as desired and, most important, scale formation is reduced, such scale as does form being removable more easily.

The process may be carried out with the aid of a reeling drum which rotates about a horizontal axis, the stock wound onto the drum being cooled at several spaced positions around its periphery. The stock is fed onto the drum by a traversing laying guide which forms a complete layer along the length of the drum before a second layer is commenced. The coiling operation is controlled to ensure that the spacing, if any, between the turns in each layer accords with the desired cooling conditions. In other words, depending upon the density of the consecutive turns partial cooling of the layer previously wound may take place while the turns in the outermost layer are being cooled.

Cooling may be carried out using a system of spray heads or discharge nozzles, which may be mounted spaced apart on a beam which extends along the length of the drum, the spray heads or discharge nozzles being located at a predetermined distance

from the surface of the outermost layer of the coiled stock.

A mechanism may be provided for moving the beam in the direction radially of the drum to ensure that this predetermined spacing remains constant. Coolant may be discharged continuously throughout the reeling operation and the spray heads are arranged to ensure that the spray pattern which is laid down on the surface of the coil extends around a predetermined circumferential extent of the coil. Each transverse segment taken through the stock wound onto the drum therefore passes repeatedly through the spray pattern, during which time it is subjected to a cooling phase, and is alternately open to the free air, during which time a temperature equalisation phase takes place. The respective sizes of these cooling and equalising zones around the circumference of the coil are chosen in accordance with the diameter and quality of the stock being coiled.

Carrying out the process described above may result in a non-uniform cooling of the stock because of differences between the cooling times of the individual turns. Furthermore, the lengths of cooling phases may be too great in comparison with the lengths of the intervening equalisation phases so that the stock is cooled at a rate below that desired to obtain the preferred structure. This problem may be overcome by providing a row of individually operable spray heads arranged along the length of the beam. The spray heads may be operated so that only the newly wound turn is subjected to cooling at any instant. In other words, the cooling operation progresses along the coil at the same rate as coiling takes place. When winding of a second layer begins, the cooling operation progresses along the coil in the reverse direction. Without precautions being taken, this procedure would result at the point of reversal of the underlying layer being given a double cooling time without a corresponding doubling of the equalising time (effected only by rotation along the periphery). The cooling effect of the appropriate spray nozzle head may be so rated as not to cause a temperature drop under point of austenite formation nor a drop under any other critical temperature.

When the diameter and quality of the stock permits a quicker change from the cooling to the equalising phase than is obtainable by the method of cooling described above, it may be performed concurrently along several sections of the length of the drum. In addition, several beams equipped with spray heads may be provided around the periphery of the drum so that cooling may be effected at different rates at different positions around the circumference of the drum. In this connection, the spray pattern formed by the spray heads provided on the various beams may overlap so that repeated cooling of one and the same layer take place.

Uniform cooling can also be achieved by arranging several beams equipped with spray heads around the drum circumference, the spray heads being made to operate on completion of a wound layer of stock, and briefly to carry out cooling during one or more revolutions of the drum. In other words, the cooling phase commences when the direction in which winding is taking place is reversed, and the equalisation phase commences when a new layer begins to be wound onto the drum.

Accordingly, it will be seen that a second aspect of the invention provides a method of cooling hot metal wire or rod leaving the final stand of a rolling mill, wherein the wire or rod is wound under tension into a coil composed of a plurality of superimposed layers of turns, the innermost layer of the coil being supported during winding; the winding operating being carried out by rotating the coil about its axis, the cooling operation being carried out using liquid coolant applied to the coil either (a) in one or more regions of each layer of turns, the or each region advancing axially of the coil and keeping pace with the winding operation, or (b) throughout the entire length of the coil after the winding of each layer has been completed.

Instead of spraying coolant onto the coil being built up on the drum, the invention may be performed by partially immersing the drum in a bath of coolant, and rotating the drum about a horizontal axis. With this arrangement, the stock wound onto the drum repeatedly passes through the coolant, so that cooling and equalising phases alternate. The length of the cooling phases may be varied by adjusting the depth to which the coil is immersed. The cooling effect can be adjusted by varying the volume of coolant supplied per unit area or unit of time from a minimum to a maximum or vice versa.

Regardless of how it is performed, the process provided by the present invention takes place in such a way that after the stock has been cooled by sprays of coolant or complete immersion in coolant, the surface zone of the coil is reheated by heat flowing from within. In this way, the uniform cooling action is obtained across the cross-section of the stock until the desired temperature is reached.

Should it not prove possible to completely cool the stock during coiling, that is, because the temperature of the coil remains too high following the period of

time during which the coil is permitted to remain at the cooling station, cooling of the coil at an accelerated rate can be carried out in one or more further cooling stations to which the coil is transferred from the first cooling station.

Once the structure of the steel has been transformed to that desired, a continuous water cooling process can be carried out provided that the steel is of a type which is not liable to crack, so that the required final temperature can be achieved as soon as possible.

The invention also provides a device for carrying out the method comprising a rotatably drivable winding drum or mandrel and a winding head for the wire or rod, the head being displaceable parallel to the axis of the drum or mandrel, and either one or more tubular beams which are disposed at a specific radial distance from the winding drum or mandrel and displaceable parallel to the axis of same, the or each beam having nozzles for spraying a coolant towards the drum or mandrel, or a container for a coolant into which a coil on the drum or mandrel can be partially and/or temporarily immersed.

The invention will now be described in greater detail but by way of example only with reference to the accompanying drawings, in which:—

Figure 1 is a transformation diagram shown the temperature/time curves for a process carried out in accordance with the present invention and various known processes;

Figure 2 is a diagrammatic side elevation of a device for use in carrying out the process in accordance with the present invention, with one side of a coolant collecting trough removed;

Figure 3 is a plan view of the device shown in Figure 2;

Figure 4 is an end view of the device shown in Figures 2 and 3, and

Figure 5 is a view similar to Figure 4 but showing a modification in which cooling is carried out by immersing the coil in a bath of liquid coolant.

Figure 1 is a transformation diagram (temperature against time) for a given grade of steel. The upper descending curve marked in chain lines represents a cooling process which takes place when the steel is exposed to still air, the lower descending dashed curves show processes carried out when the steel is subjected to a continuous cooling process using a liquid coolant, while the two descending curves drawn in solid lines represent a cooling process carried out in the manner to be described herein.

It will be seen that when cooling takes place with air as the cooling medium, the undesired austenitic structure does not form but the cooling process itself is too prolonged to be economically desirable. When the steel is cooled continuously using a liquid coolant, the length of the cooling process is short but the transformation curve passes through the zone in which the undesired austenitic structure forms. With the process in accordance with the invention, however, the overall length of the process is substantially reduced but the transformation curve lies outside the austenitic zone so that the finished steel has a predominantly pearlitic structure. The upper of the solid curves designates the temperature at the core of the stock while the lower curve designates the surface temperature.

Referring now to Figures 2 to 4, a cooling apparatus comprises a reeler 1 having a coiling drum or mandrel 2 to which wire 3 is fed from a traversable winding head 4 to form a coil 5. The winding head 4 repeatedly traverses from one end to the drum and then back again so that thin steel stock in the form of wire or rod is laid down in superimposed layers as is more clearly seen in Figure 3. The lower part of the coil is enclosed within a vessel or trough 6, only half of which is shown in the drawings and within which is mounted at least one (in the illustrated case, three) hollow beams or tubes 7 which extend alongside the drum and are provided with nozzles 8 for the discharge of liquid coolant, particularly water "M" supplied to the interior of the beams. The nozzles discharge the coolant in the form of sprays 9 which fan out to impinge in the form of elongate spray patterns of limited circumferential extent on the outer surface of the coil. The liquid collects at 10 in the trough 6. As described above, the position of the beams relative to the axes of the drum may be adjustable and the discharge from individual nozzles or groups of nozzles may be controlled so that the circumferential extent and/or intensity of coolant in a part of the spray pattern is adjustable. The beams 7 are displaceable by means not shown so that the distance between the nozzles 7 and the outer surface of the coil remains constant at a distance "J".

In operation the stock is sprayed while it is wound onto the drum and it will be appreciated that each segment of stock is subjected repeatedly and alternately to cooling and temperature equalization phases from the moment it has been wound onto the drum until it is covered by a subsequent layer, the equalisation phase taking place during the time that the segment passes from one spray pattern to the next. Assuming that an adequate space is left between adjacent turns, the underlying layers also experience these phases.

During the equalisation phases the heat within the stock flows outwards to reheat the surface of the stock and ensure a uniform cooling.

In the modification shown in Figure 5, the spray nozzles are dispensed with and the cooling phase is brought about by immersing the lower part 12 of the coil partially in a bath of coolant 11 contained in the trough or vessel 6. Each segment of the coil is as before subjected to alternate cooling and equalisation phases. The stock may be wound onto the drum sufficiently loosely to ensure that the underlying layers are also subjected to the cooling effect of the coolant.

The cooling action may be varied by providing a greater or lesser number of beams 7, by varying the quantity of coolant discharged or by adjusting the depth of immersion of the coil into the coolant in the case of the embodiment shown in Figure 5, whereby the process can be varied at will to suit the process requirements.

WHAT WE CLAIM IS:—

1. A method of cooling hot metal wire or rod leaving the final stand of a rolling mill, wherein the wire or rod is wound under tension into a coil composed of a plurality of superimposed layers of turns, the innermost layer of the coil being supported during winding; the winding operation being carried out by rotating the coil about its axis, the cooling operation being carried out using liquid coolant applied to the coil, either (a) in one or more regions of each layer of turns, the or each region advancing axially of the coil and keeping pace with the winding operation, or (b) throughout the entire length of the coil after the winding of each layer has been completed.

2. A method as claimed in any preceding claim, wherein the wire or rod is wound onto a drum rotating about a horizontal axis.

3. A method as claimed in claim 1 or claim 2, wherein cooling is carried out at predetermined spacings around the winding drum circumference.

4. A method as claimed in any preceding claim, wherein the spacing between the turns wound onto the drum is adjusted in accordance with the desired cooling conditions.

5. A method of cooling hot metal wire or rod leaving the final stand of a rolling mill, wherein the wire or rod is wound under tension into a coil composed of a plurality of superimposed layers of turns, the innermost layer of the coil being supported during winding; the winding operation being carried out by rotating the coil about its axis; the cooling operation being carried out using liquid coolant in such a way that each segment of each turn of the coil is subjected alternately to a cooling phase (which it is subjected to the action of coolant) and a temperature equalisation phase.

6. A device for carrying out the method according to any preceding claim, comprising a rotatably drivable winding drum or mandrel, and a winding head for the wire or rod, the head being displaceable parallel to the axis of the drum or mandrel, and either one or more tubular beams which are disposed at a specific radial distance from the winding drum or mandrel and displaceable parallel to the axis of same, the or each beam having nozzles for spraying a coolant towards the drum or mandrel, or a container for a coolant into which a coil on the drum or mandrel can be partially and/or temporarily immersed.

7. A device according to claim 6, characterised in that the beam or each beam is provided with a row of individually operable spray heads.

8. A method as claimed in claim 1 and substantially as hereinbefore described with reference to the accompanying drawings.

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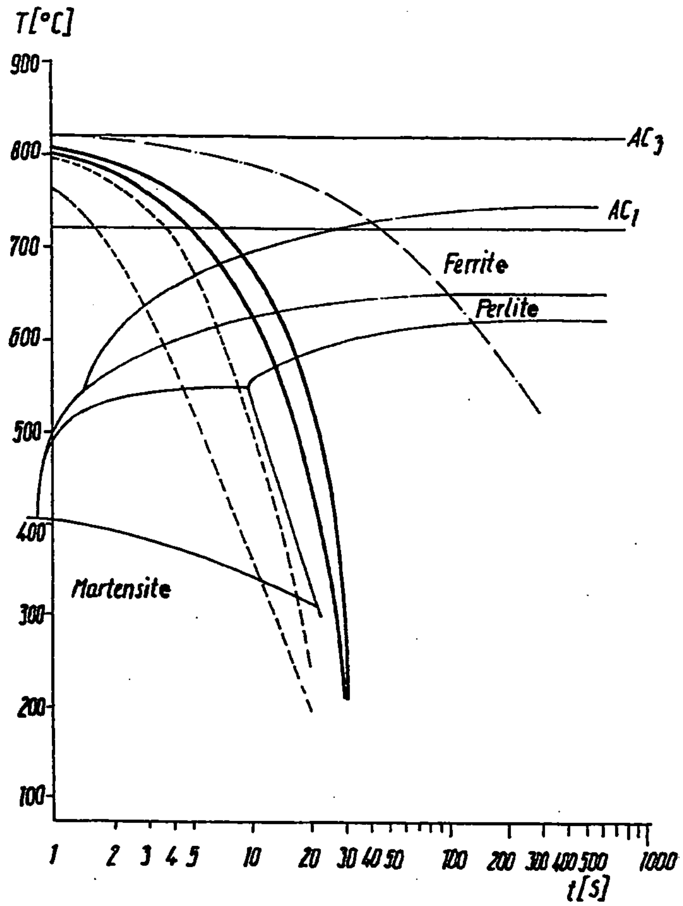
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Fig. 1

1446946 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 2